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1. Your reference S12CISR6

2. Patent application number *(The Patent Office will fill in this part)* 0412627.2

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
Dr DAN MERRITT
139 BAGINTON ROAD, COVENTRY, CV3 6FY, U.K.

Patents ADP number *(if you know it)* 552962 3003

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention INTERNAL COMBUSTION ENGINE

5. Name of your agent *(if you have one)* ~~APPLICANT'S ADDRESS~~

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
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Description	7
Claim(s)	2
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11. I/~~We~~ request the grant of a patent on the basis of this application.

Signature D. Merritt Date 4th JUNE 2004

12. Name and daytime telephone number of person to contact in the United Kingdom DE Dan Merritt, TN: 02476410384, Fax:02476411263 e mail: MerrittEngine@aol.com

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INTERNAL COMBUSTION ENGINE

This invention is an improvement to patent application (GB) 0326916.4 filed on 11th November 2003.

This invention relates to spark ignited reciprocating internal combustion engines operating on both the four stroke and two stroke cycles.

In particular it relates to lean-burn engines, capable of operating at part load without using a throttle valve to restrict air intake. It uses fuel injection into an indirect combustion chamber where spark ignition takes place. It is suitable for use in automotive applications with gasoline fuel.

Lean-burn engines can achieve an improved thermal efficiency at part loads by reducing pumping work at part load and by reducing the heat loss soon after combustion since the products of combustion are cooled when mixed with excess air. An indirect combustion chamber also reduces heat loss by containing the flame within a smaller surface area compared with a direct combustion chamber.

The improvement clarifies an embodiment which was disclosed in application GB 0326916.4 but was not sufficiently described. It should enable the engine to extend the lean burn capability.

Some methods used so far to promote lean-burn in spark ignition reciprocating engines are not wholly satisfactory. This invention offers improved overall performance with potential to promote reliable spark ignition and stable combustion over a wide operational range including idling conditions. Accordingly, this invention provides an internal combustion engine comprising:
a piston reciprocating in a cylinder;
air inlet means communicating with the cylinder;
exhaust means communicating with the cylinder;

an indirect combustion chamber communicating with the cylinder comprising a near end and a far end in relation to the piston;
transfer orifice means communicating with the cylinder and the combustion chamber at its near end;
one or more spark ignition means communicating with the combustion chamber;
fuel injection means communicating with the combustion chamber;
management means to control the fuel injection process and spark ignition event or events;

characterised in that the transfer orifice means is adapted to deliver a jet of air into the combustion chamber during the compression stroke of the piston forcing gas movement around the periphery of the combustion chamber in helical swirl motion in the axial direction away from the near end and in that the fuel injection means is adapted to deliver some fuel into the said jet of air within the combustion chamber in a direction which also enables a spark ignitable mixture to form in the gas arriving at the spark ignition means.

Preferably the spark ignition means is a spark plug situated at or in the vicinity of the far end of the combustion chamber;

Preferably the fuel injection means is an electrically actuated injector situated at or in the vicinity of the near end of the combustion chamber in a direction pointing towards the far end of the chamber and is also adapted to deliver a spray of fuel at the jet of airflow emerging from the transfer orifice means into the combustion chamber during the compression stroke of the piston.

Preferably the management means provides control of both the timing and duration of fuel injection and where necessary also the pressure of fuel supply to the fuel injector.

The term air is used herein to describe air which is either pure or contains other gases such as products of combustion or even hydrocarbon gases. The term mixture described air mixed with vaporised fuel destined for combustion. The term lean mixture is used to describe gas

that is not ignitable by the spark ignition means used in the engine The term gas is used to describe either air or any mixture.

The term near end herein describes the end of the combustion chamber situated nearer the piston and the transfer orifice means. The terms far end herein describes the end of the combustion chamber situated opposite the near end, furthest from the transfer orifice means.

The term chamber herein describes the combustion chamber and the term orifice describes the transfer orifice means.

The term lean burn capability is used herein to describe the ability of an engine to perform with an overall lean mixture by using stratification.

The term helical swirl is used herein to describe gas movement in the combustion chamber induced by the air jet emerging from the transfer orifice means. The jet is aimed with a tangential velocity component to produce rotation around the periphery of the combustion chamber as well as an axial velocity component to produce cork screw like motion towards the far end of the combustion chamber. On reaching the far end the gas continues in its peripheral rotation and the gas arriving from behind presses against the gas in front as its axial momentum is absorbed. This may result in a degree of stacking, so that some of the gas arriving later remains at least partially separated from the gas which arrived earlier, so providing a degree of stratification.

The term stratification is used herein to describe gas movements which promote a non-homogeneous blending of fuel and air within the combustion chamber volume so that a spark ignitable mixture ends up near the spark plug when the piston is at or near the end of the compression stroke and air or lean mixtures end up elsewhere within the combustion chamber.

The terms air jet is used herein to describe the air emerging into the combustion chamber from the transfer orifice means during the compression stroke of the piston.

The aim of the invention is to provide a spark ignitable mixture at the spark plug over a wide range of fuelling including idling conditions. It aims to enable fuel to vaporise and mix with some of the air to form a mixture capable of combustion under lean overall conditions, whilst

keeping the remainder of the air from over diluting the mixture to the point where combustion becomes erratic.

This aim is achieved by utilising the capability of helical swirl flow around the periphery of a combustion chamber, preferably cylindrically shaped, to stratify the air delivered at the early part of the compression stroke towards the far end of the chamber and to stratify the air delivered at the end of the compression stroke in the vicinity of the near end of the combustion chamber. The timing of fuel injection can influence the position, along the axis, of the resulting mixture rotating around the periphery of the chamber.

Fuel injection aimed at the far end of the chamber, is delivered preferably during the early part of the compression stroke when the engine is idling. At that time the air jet emerging from the transfer orifice means has insufficiently momentum to entrain the spray of fuel directed at it. This allows the fuel spay to reach the far end of the chamber in the vicinity of the spark plug. The air rotating at the far end will vaporise some or all of the fuel including some or all of the fuel which may have been deposited on the wall of the chamber. The proximity of the resulting mixture to the spark plug allows ignition even under idling conditions. Preferably this may be achieved without restricting the air intake to the cylinder during the induction stroke.

It has been observed by experiments on a prototype engine constructed according to this invention that the air jet emerging from the transfer orifice means reaches its maximum velocity and density near the end of the compression stroke. During the earlier part of the compression stroke the ability of this jet to absorb and vaporise fuel injected at high pressure is therefore greatly reduced. When operating at the extreme lean burn conditions at idling it was found that fuel injected into the jet along its axis, as described in Claim-2 of patent application 0326916.4 failed to reach the spark plug as an ignitable mixture formed within the jet, when the spark plug was situated at the far end of the combustion chamber. This spark plug position allowed reliable spark ignition at high engine speeds since the gas velocities in that location were smaller. Consequently an injector positioned according to claim-2 was found to impair the capability of the engine to idle unthrottled and also operate at high speeds but positioning the fuel injector according to claim-1 and Claim 3 of patent application 0326916.4, can provide a solution to this problem.

This invention is further described herein by the way of examples, with references to the accompanying schematic drawings which are not to scale and are presented for illustration purposes only;

Figure1 is a partial section through a combustion chamber and part of the cylinder of internal combustion engine according to this invention.
Figure 2 illustrates a sectional view along line A-A of Figure 1 of a similar combustion chamber.
Figure 3 is a sectional elevation similar to figure 1 but with a different orientation of the fuel injector.
Figure 4 is a sectional elevation of a two stroke engine constructed according to this invention.
Referring to the drawings by the way of examples, Figure 1 shows a cylindrical combustion chamber 6 with its axis 19 set at an angle to axis 18 of cylinder 2 in order to achieve a desired angular inclination H between the axis 20 of the transfer orifice 7 and the combustion chamber's axis 19.
Inclination H affects the helical swirl motion of the gas entering the combustion chamber from cylinder 2 during the compression stroke of piston 1 (shown in figure 3). Figure 1 is a section taken through the axis of symmetry 19 of the combustion chamber and does not contain the axis of symmetry of cylinder 2. The transfer orifice means 7 is seen entering the chamber in the vicinity of its near end 8 in a direction pointing a jet of air to rotate around the periphery 22 of the cylindrical combustion chamber in helical swirl flow towards the far end 10. The fuel injector 11 is shown pointing a spray (not shown) towards the far end 10 but it is also positioned to intersect the jet of air whose curved axis 14 (see Figure 2) intersects the injector's axis at point W so as to entrain much of the fuel spray when the air jet's velocity becomes sufficient for this purpose. It is not necessary for the two axes actually to intersect at point W as shown but is an advantage to point the injector so that as much of the fuel spray meets with the air jet in order to maximise rapid fuel vaporisation.

Figure 2 shows a cross section along line A-A shown in Figure 1. It shows a similar embodiment not an identical one. Figure 1 is itself a section along line B-B shown in Figure 2. Axis 20 is shown entering the combustion chamber tangentially, at angle S, in order to promote swirl around the periphery 22 of the combustion chamber 6. The curved axis of the

air jet is shown as streamline 14intersecting the axis of the fuel injector 11 at point W and the injector is shown inclined towards the far end 10 of the chamber. The flame plate 5 of cylinder 2 is shown but the inlet and exhaust valves which seal against it are missing.

Figures 1 and 2 in combination illustrate how helical swirl motion is engineered to give an optimum value. Angle S is required in order to promote swirl and angle H is required to promote axial movement hence helical swirl motion in combination. The severity of the motion is influenced not only by these two angles but also by the proximity of the edge of orifice 7 to the peripheral wall 22 at entry as well as the cross sectional area of orifice 7.

Figure 3 illustrates by way of an example an alternative position and orientation for the fuel injector 11. It is shown aimed at the spark plug 9 at the far end 10 but its position at the near end 8 is not on the central axis 19 (see Figure 1) of the combustion chamber 6, as it appears to be on the simplified illustration. It is offset from the central axis in a position facing the entry of transfer orifice 7, which enters the combustion chamber tangentially as shown in Figure 2. In this position the fuel spray can meet the air jet soon after it enters the combustion chamber. When fuel is injected early in the compression stroke the spray, which is aimed at the periphery of the combustion chamber 22 near the far end 10 in the vicinity of the spark plug, can be delivered directly to that region. The helical swirl motion of air, shown in stream-line form 14, will collect this fuel near the far end, vaporise and retain it at the far end whilst the remainder of the air swirling behind without fuel becomes stratified from the mixture.

The timing and duration of fuel injection, which is governed by the management means, is important to ensure good performance under all engine loads. When idling, fuel can be injected for a short time during the induction stroke or the early part of the compression stroke. The stratifying effect of helical swirl provides a mechanism for vaporising this fuel and retaining it is swirl motion as a mixture in the vicinity of the spark plug to effect ignition, even when most of the combustion chamber's volume is filled with air without fuel.

When load is increased, the duration of fuel injection is also increased. It must stop just before the end of the compression stroke, and if necessary, the fuel line pressure is increased to ensure the delivery of the required quantity of fuel. At the early part of the compression

stroke fuel is sprayed towards the periphery 22 of the chamber and is absorbed into air swirling around the periphery but as the compression stroke progresses increasing amount of fuel becomes entrained into the air jet emerging from the transfer orifice 7 as its momentum increases.

Figure 4 illustrates the application of this invention to one embodiment of the familiar two stroke engine when modified to take advantage of the improvements according to this invention. The numbering of items which appear in other diagrams as well remains identical.

Air enters the crankcase through inlet port 3 provided with a non return valve 30 during the compression stroke of piston 1. Unlike conventional two stroke engines the air intake is left unthrottled at part load and is not mixed with any fuel. When the transfer port 31 is uncovered by the piston near the end of its subsequent expansion stroke the air is transferred into cylinder 2 and is deflected into a loop scavenge flow direction by projection 33 situated on the crown of piston 1. When the piston covers the exhaust port 4 during the early part of its compression stroke, or even earlier, the fuel injector 11 can start injecting fuel into combustion chamber 6 and when required can continue to do so until near the end of the compression stroke.

It is advantageous to minimise the volume in cylinder 2 at the end of the compression stroke in order to deliver the maximum amount of air into the combustion chamber and the shapes of projection 33 and recess 34 can be made similar in order to achieve this aim.

This arrangement removes disadvantages inherent in the conventional two stroke design one being the presence of fuel in cylinder 2 during the blow down period and the other being the need to throttle the air intake at part load. The stratified charge capability and efficient fuel preparation should offer a two stroke engine modified according to this invention much improved thermal efficiency, cleaner exhaust and high speed operation.

CLAIMS

1. An internal combustion engine comprising
a piston reciprocating in a cylinder;
air inlet means communicating with the cylinder;
exhaust means communicating with the cylinder;
an indirect combustion chamber communicating with the cylinder comprising a near end and a far end in relation to the piston;
transfer orifice means communicating with the cylinder and the combustion chamber at its near end;
spark ignition means communicating with the combustion chamber;
fuel injection means communicating with the combustion chamber;
management means to control the fuel injection process and spark ignition event or events;
characterised in that the transfer orifice means is adapted to deliver a jet of air into the combustion chamber during the compression stroke of the piston forcing air movement around the periphery of the combustion chamber in helical swirl motion in the axial direction away from the near end and in that the fuel injection means is adapted to deliver some fuel into the said jet of air within the chamber in a direction which also enables a spark ignitable mixture to form in the gas arriving at the spark ignition means.

2. An engine according to claim 1, wherein the said fuel injection means is situated to deliver fuel into the said jet of air at an angle to the axis of the said jet.

3. An engine according to claim 1 wherein the said fuel injection means is situated to direct fuel delivery towards the far end of the combustion chamber.

4. An engine according to any of the preceding claims wherein the clearance volume above the piston at the end of the compression stroke is minimised within mechanical constraints.

5. An engine according to claim 1 and claim 4 wherein the fuel injection means is situated to deliver fuel directly towards the said jet of air along an axis coincident or parallel with the axis of the said jet.

6. An engine according to any of the preceding claims wherein the said spark ignition means is situated at or in the vicinity of the far end of the said combustion chamber.

7. An engine according to any of the preceding claims wherein the said spark ignition means is situated at or in the vicinity of the near end of the said combustion chamber.

8. An engine according to any of the preceding claims wherein two spark ignition means are used to effect ignition at two different locations.

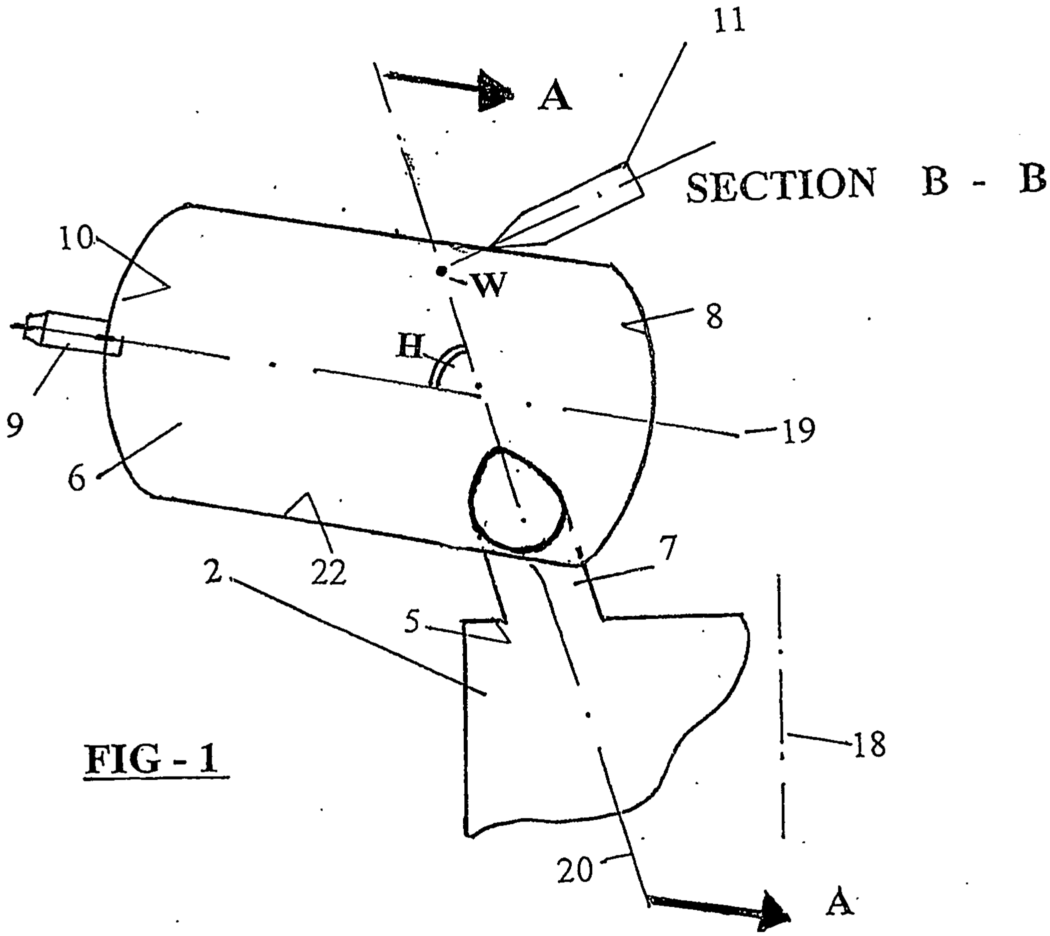
9. An engine according to any of the preceding claims operating either on the four stroke cycle or on the two stroke cycle.

10. An engine according to the preceding claims wherein air induction into the cylinder is not restricted in order to operate at part load.

ABSTRACT

INTERNAL COMBUSTION ENGINE

A high efficiency lean-burn spark- ignition two or four stroke engine operable unthrottled suitable for vehicles using gasoline. It uses an indirect combustion chamber and a transfer orifice aligned to produce a jet of air moving in helical swirl motion around the chamber during the compression stroke. Fuel is injected into the chamber aimed into the air jet to assist rapid vaporisation. The position and orientation of the fuel injector ensures that fuel arrives near the spark plug even under idling conditions and the helical swirl flow ensures the stratification of the ignitable mixture formed near the plug.


11
A
SECTION B - B
10
W
8
H
9
19
6
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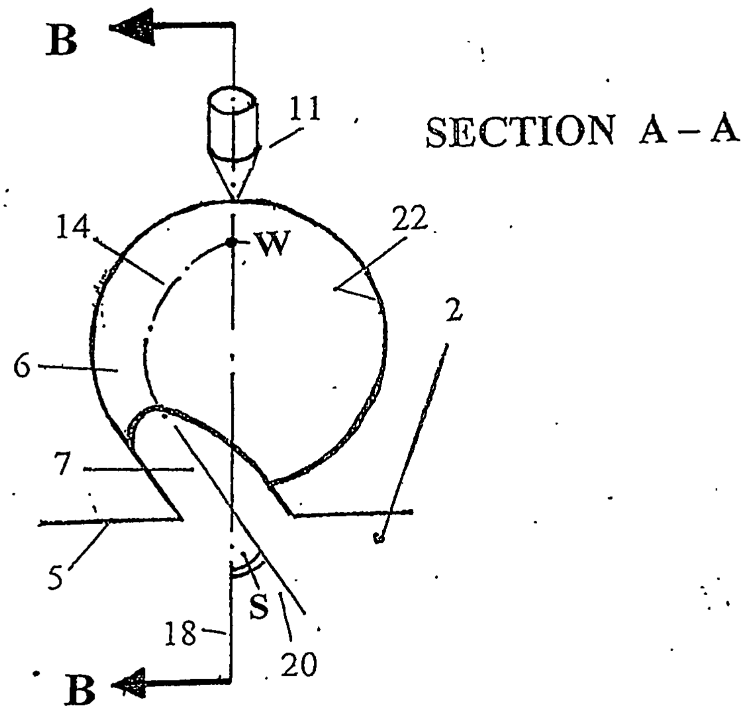
22
5
18
20
A

FIG - 1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W
22
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FIG - 2

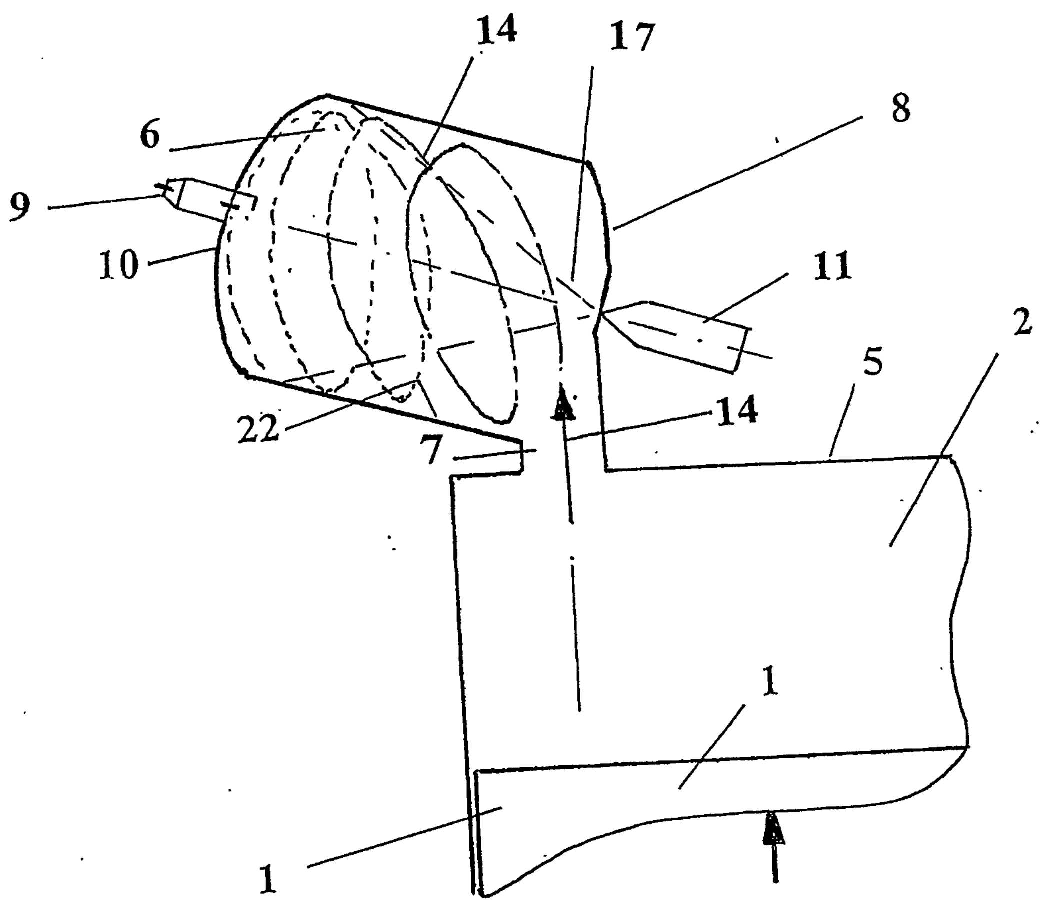

FIG. 3

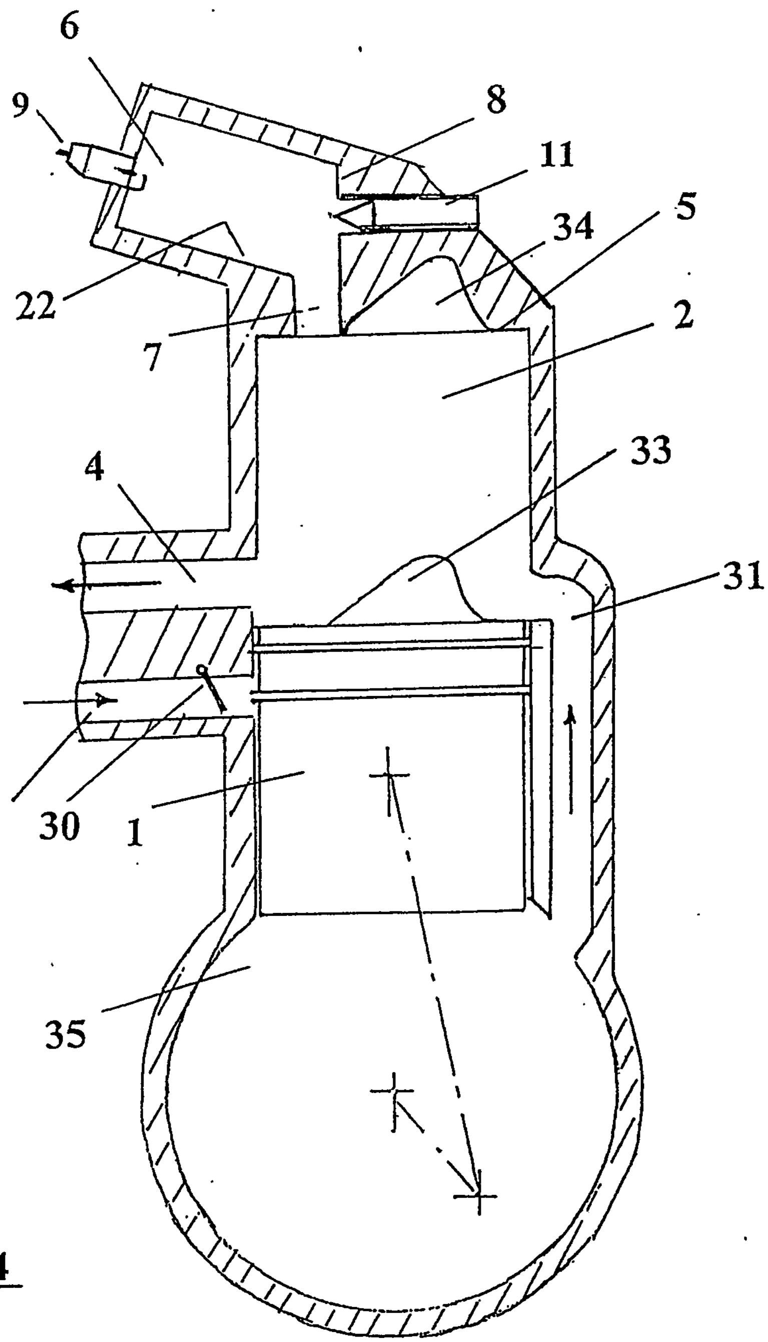

FIG - 4

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